

DYNASIM[©]

**An Interactive, Physics-Based,
Real-Time Ship Simulator**

for Windows NT/2000/XP Platform

User Manual

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Version 3.2

August 2006

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Abstract

This manual provides a description of DYNASIM[®]. The code is designed to simulate multi-ship dynamics in restricted water, in the presence of waves, wind, currents, and obstacles. General topography, channel configuration, and environmental conditions can be input by the user. The simulator can be used to generate multiple ship tracks to evaluate harbor safety from a system perspective and estimate the likelihood of collision for various types of vessels, traffic densities, navigation channels geometries and environmental conditions. It can also be used for continual training of masters and pilots to minimize human error, and by harbor designers and port managers for structures and waterway design, modification, improvement and implementation of safety measures. This manual also explains how to prepare input files, how to run the code, and what results can be output. Sample input and output files are provided. These example input and output files and the software are provided on the program disks

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1. Introduction

The PC Windows Ship Maneuvering Simulator, DYNASIM[®], is a user friendly ship dynamics simulator that will incorporate Systems Identification Techniques in future versions to determine ship maneuvering characteristics. Once the parameters are known the simulator reproduces ship motion under the action of waves, wind, nearby piers, obstacles or other ships, it is presently able to operate in three modes: user manually controlled, standard ship classification maneuvers (i.e. tests recommended by the International Maritime Organization for evaluating the maneuverability of a ship), and computer controlled maneuvers including prescribed routes and obstacle avoidance. Multithreading enables simultaneous simulation of several ships. DYNASIM[®] incorporates on-screen buttons for maneuvering controls and input of environmental conditions, which helps personnel training, ship design, and navigation planning. The initial efforts to develop the device were funded by Small Business Innovation Research (*SBIR*) awards from the National Science Foundation, the Department of Defense, and the National Oceanic & Atmospheric Administration.

2. Technical Basis

The simulator is based on the state-of-art knowledge of ship dynamics. A comprehensive model for ship dynamics under cruising and maneuvering conditions is implemented. It incorporates a large variety of options to simulate vehicles (large ships and small boats), with different engine types, weather and sea conditions, and land and coastal configurations. Some of the navigation code rules have been implemented for allowing auto piloting of multiple ships in the computer controlled mode.

The hydrodynamic characteristics implemented in DYNASIM[®] can be updated using the results from the advanced computational hydrodynamics code developed at DYNAFLOW, INC., 3DYNAFS[®], which can handle nonlinear, large amplitude vehicle motion, high waves, surf zone waves, etc. An additional

major characteristic of future versions of DYNASIM[®] is its incorporation of a multi-objective system identification technique to determine the vehicle parameters. This would enable the autopilot to adjust the vehicle parameters based on feedback from the ship response to the pilot commands.

The simulator employs modular mathematical models for the various components of the ship (hull, propeller(s), rudder(s), and thrusters) and environmental effects (wind, current, waves) and waterway (bottom, pier walls) to achieve a sophisticated mathematical model for the ship. The models are based on collective experience resulting from development of many simulators.

3. Installation

DYNASIM[®] operates on a PC under Windows NT 4 and up. The software is operated and controlled through a user-friendly Graphical User Interface (GUI). The various options and tasks are accessed through a series of pull down menus and easy-access buttons.

The following simple steps will guide the user through the installation process.

1. To install this software, user needs to be logged in as an “administrator” or have administrator rights.
2. Open the folder of the distribution CD, the following files should be readily located:
OCX.bat, AX_UG.ocx, ACWAnim.ocx, HeadingControl.ocx, REGSVR32.EXE
3. Double click the batch file “**OCX.bat**” to install the above three ocx files to the system automatically. If the batch file runs successfully, a message box with “*DLLRegisterServer in AX_UG.ocx succeeded*” will appear, click OK and continue until all three ocx files are installed successfully. If all three ocx files are installed successfully, go to step 5.
4. If the batch file doesn’t run successfully, the three ocx files have to be installed manually. To do so, copy the three ocx files to the *SYSTEM32*

folder (either *C:\WINNT\SYSTEM32* for *Windows NT* or *C:\WINDOWS\SYSTEM32* for *Windows XP*). If **REGSVR32.EXE** is not present in the *SYSTEM32* folder, also copy it from the CD to the *system32* folder.

Then, open a console window for a command prompt (Start → Run → type “cmd” → OK) and change directory to the *SYSTEM32* folder, and execute the following command:

REGSVR32.EXE AX_UG.ocx

After getting the message “*DLLRegisterServer in ACWAnim.ocx succeeded*”, continue to register the second and third OCX files, i.e.,

REGSVR32.EXE ACWAnim.ocx and

REGSVR32.EXE HeadingControl.ocx.

5. Put the executable **DynaSIM.exe** in the directory of the user’s choice.
6. Put all ship model files ***.shp** (i.e., **Mariner.shp**, etc.) and itinerary files ***.env** (i.e. **Sample Itinerary 1.env**, etc.) in the working directory where the user wants to make runs and place all the input and output files.

Now, the user is ready to use DYNASIM[®].

4. Running DYNASIM[®]

Double clicking on the DYNASIM[®] icon to start the DYNASIM[®] software. This invokes the Graphical User Interface allowing for interactive and arbitrary manipulation of the on-screen control/steering devices in real time, and a graphical display of multiple ships and sea environments. A snap shot of the typical working window of DYNASIM[®] is shown in Fig.1. The scale of one grid spacing is shown on the upper left corner, and it changes according to the grid as the user zooms in and out the view.

4.1 Setup of the environment

By clicking the shortcut buttons on the left side of the window, the users can set up the surrounding environment, in which the simulation will be conducted. These buttons are described below.

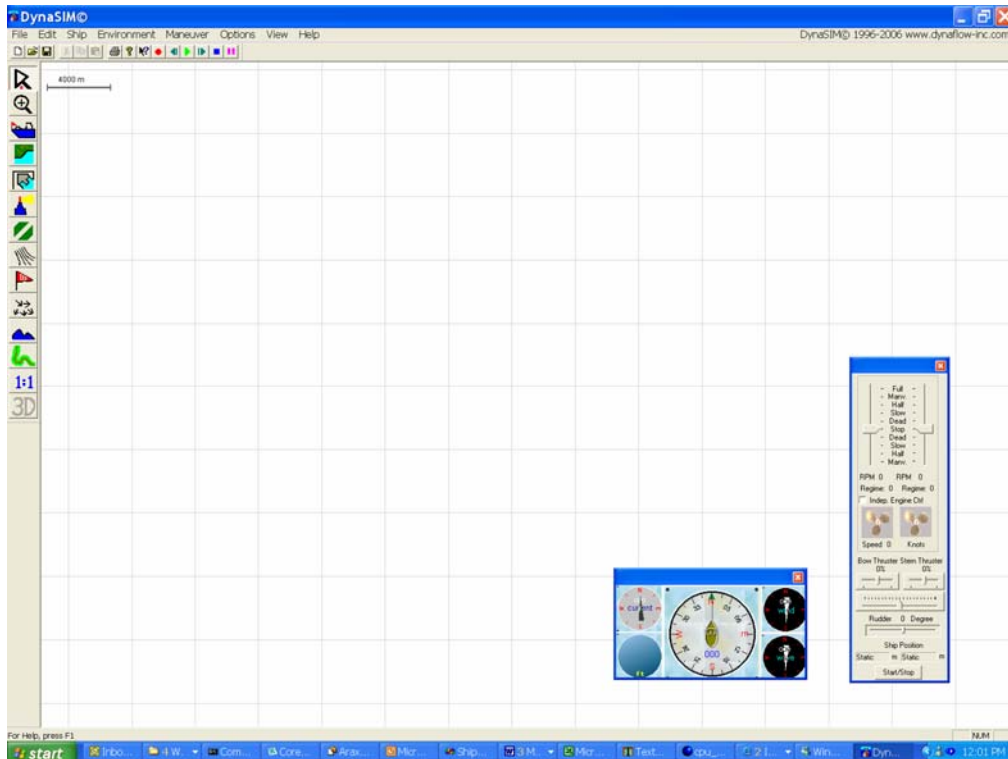


Figure 1. Initial window of DYNASIM[®] after starting the program.



Zone Selector

After the environment has been set up, if a change to the properties of a certain zone is desired, just highlight this button, then place the cursor inside of the zone that needs to be changed and double click the left mouse button, a property change dialog window will pop up, in which the user can change the properties of the zone, delete the zone, or shift the zone by a specified distance.

Another way to shift the whole zone to a desired new place is to drag the zone when both left and right mouse buttons are pressed. Release the mouse buttons when the zone has been dragged to the desired place. If the user only wants to change one zone point to a new place, he can put the cursor on that point, drag the mouse to the desired place while the right mouse button is pressed down.



Insert Shore

Click this button, then place the cursor to the desired location in the simulation area and left click the mouse to plot a shore area by connecting segments to form a closed area. A colored area representing the shore appears in the window.



Insert Harbor

Click this button, then point the cursor to the desired location in the simulation area and left click the mouse to plot a harbor area. A colored area representing the harbor appears in the window.



Insert Lighthouse

Click this button, then point the cursor to the desired location in the simulation area and left click the mouse to insert a light house.



Insert Iso-Depth

Figure 2. Input of iso-depth properties.

Click this button, then point the cursor to the desired location in the simulation area and left click the mouse to plot an area that has a given constant water depth. When the user finishes drawing the closed curve, a

dialog box will appear as shown in Fig. 2. Type in the value (in feet), and click OK. A colored area with the depth value is shown on the window. The same dialog window appears when the user wants to change the properties of the iso-depth zone using the zone selector.



Insert Iso-Winds

Click this button, then point the cursor to the desired location in the simulation area and left click the mouse to plot an area on which the effect of a wind with constant strength and given direction is modeled. When the user finishes drawing the closed curve, a dialog box will appear as shown in Fig. 3. Type in the direction (in degree, relative to the north clockwise), velocity magnitude (in knots), and click OK. A colored area with the values is shown in the window. The same dialog window appears when the user wants to change the properties of the iso-wind zone using the zone selector.

Figure 3. Input of iso-winds properties.



Insert Iso-Current

First click this button, then point the cursor to the desired location in the simulation pane and left click the mouse to plot an area, on which the effect of a current with a constant velocity and a given direction is modeled. When the user finishes drawing the closed curve, a dialog box will appear as shown in Fig. 4. Type in the direction (in degrees, relative to the north clockwise), velocity magnitude (in knots), and click OK. The same dialog window appears when the user wants to change the properties of the iso-current zone using the zone selector.

Figure 4. Input of iso-current properties.



Insert Iso-Waves

Click this button, then point the cursor to the desired location in the simulation area and left click the mouse to plot a area, on which the effect of a wave with a constant height and a given direction is modeled. When the user finishes drawing the closed curve, a dialog box will appear as shown in Fig. 5. Type in the direction (in degrees, relative to the north clockwise), choose the Sea State, and click OK. A colored area with the values is then shown in the window. The same dialog window appears when the user wants to change the properties of the iso-waves zone using the zone selector.

Figure 5. Input of iso-wave properties.



Insert Itinerary

Prescribed itinerary are required to run the simulator in computer controlled maneuvering mode. To add an itinerary, click this button, then point the cursor to the desired location in the simulation area and left click the mouse to plot an itinerary as desired. A safe navigation zone is required to each itinerary, when the user finishes drawing the itinerary, double click the right mouse button, a safe zone dialog box will appear as shown in Fig. 6. Type in the range of the safe navigation zone (the width) and the recommended speed for each segment of the itinerary, and click OK. A colored itinerary with the itinerary number is shown in the window. The same dialog window appears when the user wants to change the properties of the safe zone when using the zone selector to change the location of the itinerary. After setting up the environment, the user can save the environment setting to a file by clicking **Environment** on the menu, choosing **Save Environment File As**, specifying the desired name of the environment file, and clicking **Save**. To load a saved environment setting, click **Environment** on the menu,

Route Properties Dialog

Route ID: 1 Route Type: ☒ Channel ☐ Open

Route Segment Properties:

Route Segment Width (m):	<input type="text" value="1000"/>	Segment ID:	<input type="text" value="1"/>	<< PREVIOUS	NEXT >>
Safe Segment Speed (knots):	<input type="text" value="5"/>	Right Slope Angle to Sea Level Plane (degree):	<input type="text" value="90"/>		
Route Segment Depth (m):	<input type="text" value="30"/>	Left Slope Angle to Sea Level Plane (degree):	<input type="text" value="90"/>		

Figure 7. Setup example of a simulation environment.

4.2. Placement of ships



Insert ship^{*}

Click this button, then point the cursor to the desired location in the simulation pane and left click the mouse to insert a ship. A dialog box appears, which allows the user to select the desired ship and operation mode (Fig. 8). The user selects the ship model for the ship to be launched from a list of ship models or by providing a ship model data file. In addition, the user can determine how the ship hydrodynamic coefficients are provided, i.e. either read from a ship model data file or calculated internally from the ship geometrical characteristics. Once a ship is defined through its ship data file and the computation method of its hydrodynamic coefficients is prescribed, the user can select from one of three types of modes to control the launched ship: *User Controlled*, *Standard Maneuver*, and *Autopilot Itinerary*.

Figure 8. Add ship dialog.

If the *User Controlled* is selected, the user can maneuver the ship through the graphic control panel using either a mouse/keyboard or a joy stick. If a joy stick is presented, it becomes the default control device. If the *Standard Maneuver* is selected, the ship can perform one of the classical

^{*} Autopilot Itinerary is available in the Traffic and Tugboat Versions only.

maneuvers used to identify the ship hydrodynamic characteristics. Three types of maneuvers are pre-programmed: **Turning Circle**, **Zigzag** and **Spiral** maneuvers. For these maneuvers the user needs to provide a rudder angle for the standard maneuver. If the **Autopilot Itinerary** is selected, the user has to define/specify an itinerary as described above for the ship before the ship can be launched. For a ship in this category, the computer will act as an autopilot to maneuver the ship along the itinerary following the navigation rules.

If **Wait signal before start** is checked, the ship won't start motion until the user clicks the **Start/Stop** button on the control panel as shown in Fig. 9. The maneuvering data of the ship in the simulation will be saved in a **trace** file (see below), the user can specify the desired **trace** file name. Click OK, the ship will be added to the simulation environment.

4.3 Operation of the user controlled ship from the control panel

DYNASIM[®] can handle both single and twin engine propulsion systems. The number of engines of a ship is provided by the number of propellers in the ship data file. The same control panel will be used for both single and twin engine ships. Fig. 9 shows the status of the control panel for a twin-engine ship (left) and a single engine ship (right).

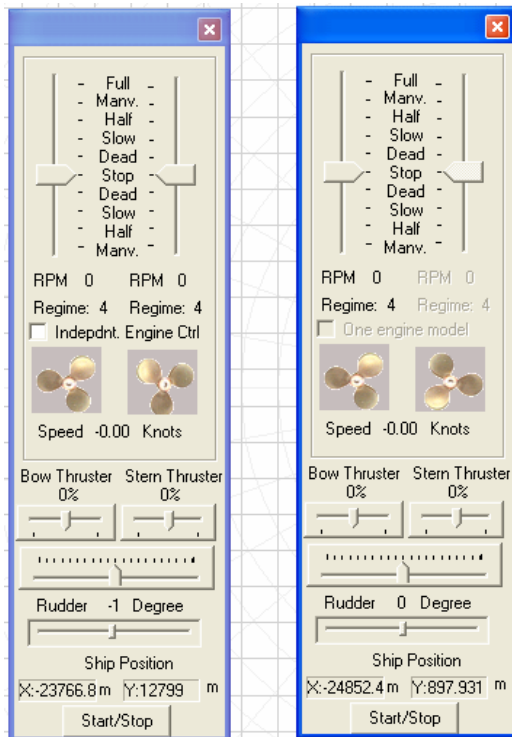


Figure 9. Control panel status for a twin-engine ship (left) and a single engine ship (right).

If the ship added is a twin-engine ship, the check box *Indepdnt Engine Ctrl* is enabled. If the checkbox is left unchecked, the two engines work in the synchronized mode, i.e. two engines are always set to the same engine throttle setting when one of the two engine throttle controls is changed. If the checkbox is checked, the user can control the two engines separately. If the ship is a single engine ship, the disabled check box will show *One engine model* and the throttle control and engine status display on the right are disabled. The single engine is controlled by the throttle control slide on the left side and the engine status is also displayed on the left.

The user can use the slide bars on the control panel to control a user-controlled ship.

Propulsion: The throttle control for the main engine is represented by the vertical slide bar in the middle of the control panel, sliding the bar enables the user to adjust the engine RPM. Sliding up from *Stop* increases the forward thrust. Sliding down from *Stop* increases the backward thrust.

The bow and stern thrusters are represented by two horizontal slide bars, sliding to the right, the direction of the thrust is toward the starboard side, sliding to the left, a thrust toward the portside is applied to the ship. The current thrust is displayed in the form of percentage of the maximum thrust that the thruster can generate.

Maneuver: The slide bar for the *Rudder Contol* is located below the thruster controls in the lower part of the control panel, sliding the bar enables the user to adjust the rudder angle to control the ship motion direction. Slide left to turn the ship to the left. Slide right to turn the ship to the right.

4.4 Operation of the user controlled ship using a joy stick

If a joystick is presented, it becomes the default control device for a user controlled ship, DYNASIM[®] can work with any generic joysticks. Fig. 10 shows a typical joystick which includes the following elements:

1. Stick (rudder)
2. Base
3. Trigger
4. Extra buttons
5. Autofire switch
6. Throttle
7. Hat Switch (POV Hat)
8. Suction Cup

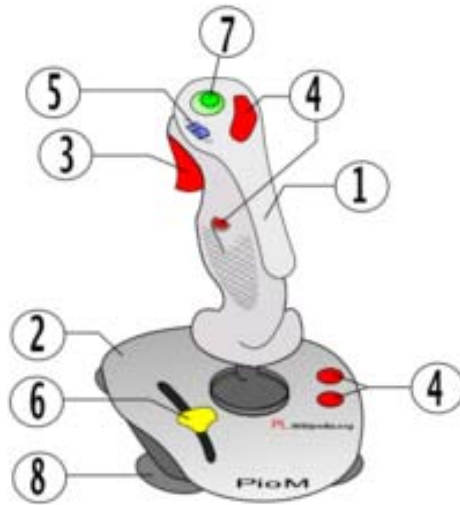


Figure 10. A typical Joystick

DYNASIM[®] uses the Stick to control the rudder. The rudder turns left or right proportionally as the stick is tilted to the left or to the right.

The propulsions in DYNASIM[®] are controlled by the combination of Throttle and POV Hat. The Throttle controls the throttle of the engines, and the selection of the engines in case of twin engines is determined by the POV Hat. When the POV Hat is in the neutral position, the main engines are controlled. When the POV Hat is push to up position, the bow thruster is controlled, when it is pulled to down position, the stern thruster is controlled. If the ship is a twin-engine ship, the left engine is controlled when the POV hat is push to left position; and when it is pushed to the right position, the right engines is controlled.

4.5 Operation of a ship in a prescribed itinerary*

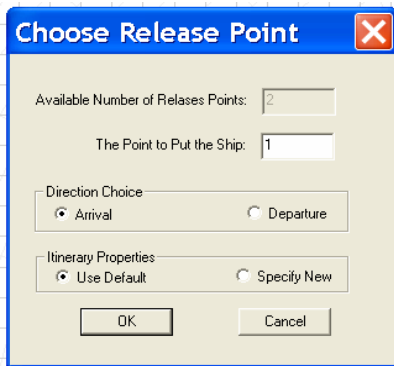
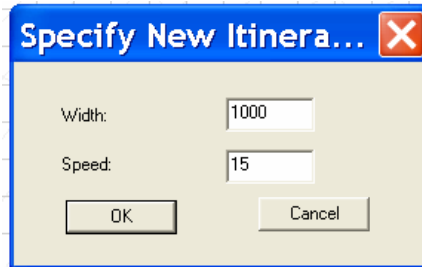
If the user specifies a ship to be launched into an *Autopilot Itinerary* when adding a ship to the simulation environment (at least one prescribed itinerary must exist, otherwise, an error will be issued), the user has the option to use the default values or specify new values for the navigation rules. If the user chooses to specify new values for these navigation rules by selecting *Specifying New Values* in the *Add Ship* dialog, a dialog window as shown in Fig. 11 pops up, through which the user can specify new values for navigation rules in different situations.

Figure 11. Specify Navigation Rules.

After the navigation rules have been decided, an itinerary selection window (Fig. 12) pops up, specify the desired route number and click OK. If a valid itinerary has been selected, a new dialog window (Fig. 13) pops up, through which the user can specify where and in which direction to launch the ship. In the same dialog window, the user can also decide whether to keep the itinerary default properties or not. If the user wants to specify new properties, he can change the properties for each segment of the itinerary through a dialog window as shown in Fig. 14.

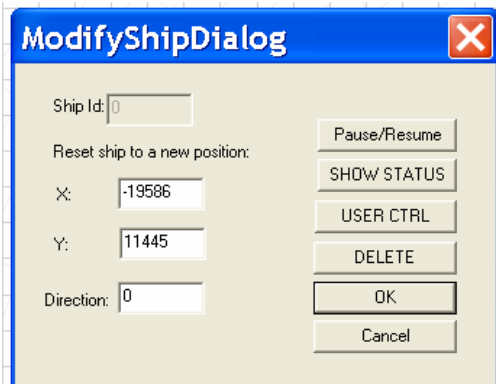
Figure 12. Choose Itinerary.

* This capability is not available in the Basic Version.

**Figure 13. Choose Release Point.****Figure 14. Specify New Itinerary Properties.**

4.4 Modification of properties of a launched ship

After a ship has been launched into the simulation environment, the user still has the capability to change the properties of the ship by pointing the cursor on the ship and double clicking the right mouse button. A dialog window as shown in Fig. 15 pops up. The user can pause or resume the motion of the ship, change the ship from the current type to another user controlled type such that he can maneuver the ship through the control panel, delete the ship from the simulation environment, display the ship status through the control panel, and relocate the ship to a desire location by providing the coordinates of the new location. The user can also drag the ship to a desired position by putting the cursor over the ship, moving the mouse while pressing the left mouse button.

**Figure 15. Modify Ship Properties.**

4.5 View options



Zoom

Click this button enables the user to zoom in and zoom out in the selected area.



Restore (1:1)

Click this button will set the view of the window to the initial setting.

4.6 Displaying the simulated time duration

DYNASIM[®] can display the duration of a ship simulated time, i.e. from the time it is launched into the simulation environment until the current time. This is shown in the Simulation Time Display window (Fig. 16). The time is displayed in *HH:MM:SS* format (HH for hours, MM for minutes, and SS for seconds elapsed). The time displayed on the window is for the same ship for which status information is displayed on the control panel (Fig. 9).

The user can show or hide this window by clicking *view* → *Show time* from the main frame as shown in Fig. 17.

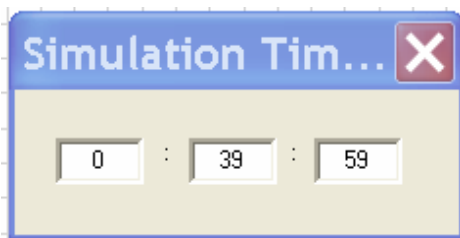


Figure 16. The time display window.

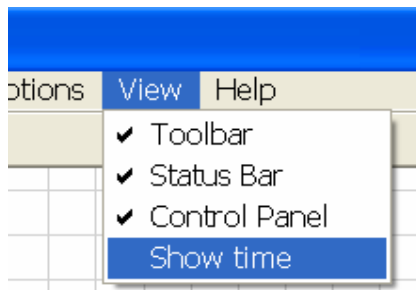


Figure 17. Show / hide time display window.

4.7 Simulation Speed Adjustment

The ship simulation proceeds in discrete time steps, the simulation time step size can be modified by clicking *Options*→*Time Step Specifications* on the main window frame. A dialog window as shown in Fig. 18 will pop up to allow the user to change the time step size which is the physical time represented by each time step. The change of time step size will apply globally to all the ships and the time step size will be maintained through the simulation until it is changed the next time.

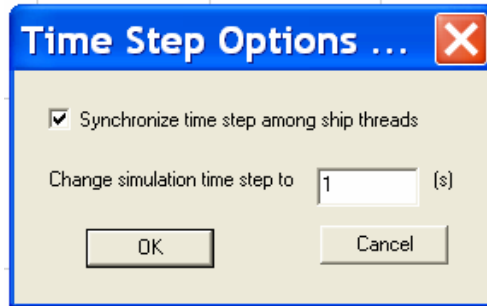


Figure 18. Time step specification dialog window.

4.8 Preparing ship characteristics data files

The turning and cruising characteristics of a ship can be used in DYNASIM[®] by overriding the default values used for route control for the ship. This information can be provided to DYNASIM[®] through three files. Followings are the detailed information of these files:

1. **Ship performance data file:** This file is named in the format of “*performance_stt_SHIPNAME.pef*”, where *SHIPNAME* should be the same as the ship data file name. For an example, if “*Mariner*” ship is selected, the ship performance data file should be named as “*performance_stt_Mariner.pef*” to be used by DYNASIM[®]. The file provides the information of engine regime and the corresponding ship speed when ship keeps a straight course at a steady state. Below is an example of “*performance_stt_Mariner.pef*” file.

```

10
5          5.94922
6          9.91509
...

```

Here, the first line is the total number of regimes the ship has, and it is followed by data pairs that specify “Engine regime” and “Ship speed”.

2. **Ship turning radius performance data file:** This file is named in the format of “*performance_rdd_SHIPNAME.pef*” where *SHIPNAME* should be the same as the ship model name. For an example, if “*Mariner*” ship is selected, the ship turning radius performance data file should be named as “*performance_rdd_Mariner.pef*” to be used by DYNASIM[®]. The file provides the information of ship turning characteristics for a given rudder angle. A sample “*performance_rdd_Mariner.pef*” file is shown below:

```

19
-40   430.431   402.315   29.17   0   204.039   22.142
-35   454.798   432.329   25.27   0   195.616   20.98875
...

```

The first line is the total number of data sets included in the file, each data set is ordered as “ θ , a_{lab} , d_{fwd} , m_{lab} , m_{lat_var} , m_{fwd} , m_{fwd_var} ”. The definitions of a_{lab} , d_{fwd} , m_{lab} , and m_{fwd} are shown in Fig. 19. θ is the rudder angle, and m_{lat_var} and m_{fwd_var} are the average variances of m_{lat} and m_{fwd} among different engine regimes. All units are meter except the rudder angle θ which is in degrees.

3. **Ship turning rate performance data file:** This file is named in the format of “*performance_trt_SHIPNAME.pef*” where *SHIPNAME* should be the same as the ship model name. For an example, if “*Mariner*” ship is selected, the ship turning radius performance data file should be named as “*performance_trt_Mariner.pef*” to be used by DYNASIM[®]. The file provides the information of ship turning rate at a given engine regime and rudder angle for steady ship turning. A sample “*performance_trt_Mariner.pef*” file should look like below:

```

105
5      -40      -0.257167

```

5	-35	-0.263259
5	-30	-0.265563
...		

Here, the first line is the total number of data sets included in the file, and each data line following the first line is composed of “*engine regime*, θ , *turning rate*” in order. Units of θ and *turning rate* are degree and degree per second, respectively.

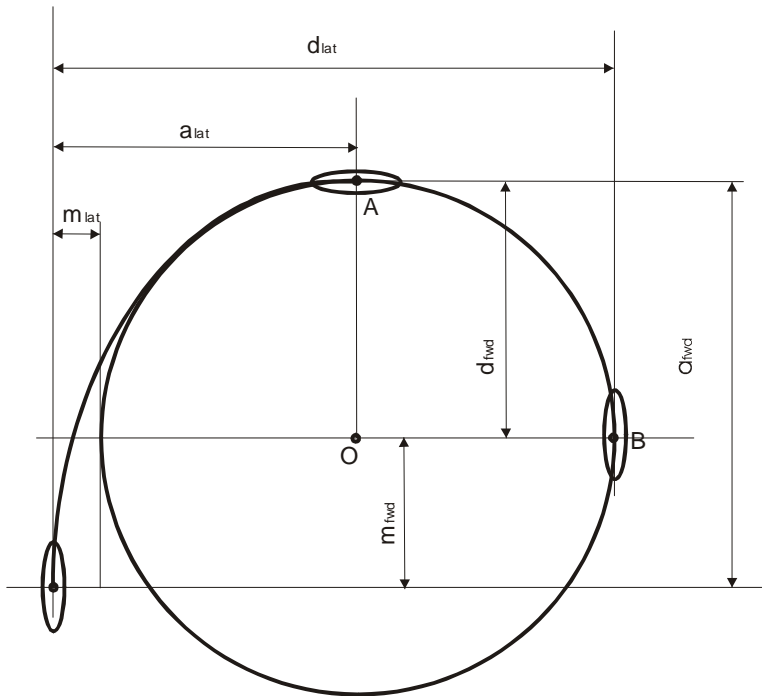


Figure 19. Ship turning characteristics.

4.9 Preparing ship data file

The specifications of ship parameters must be prepared in a ship model file, *.shp. For example **Mariner.shp** has the following values. The user can modify the values of the parameters according to their requirements.

<Hull data>

```
167.880005, [1 length          ]
23.200001,  [2 beam            ]
7.400000,   [3 draftb          ]
8.100000,   [4 drafts           ]
16818.000000, [5 displacement   ]
1800.000000, [6 lateral_above_ ]
240.000000,  [7 transverse_ ]
-3.500000,   [8 center_pressure_location ]
10.000000,   [9 dist_from_air_to_base ]
-16.500000, [11 Xg              ]
3.000000,   [12 Ho              ]
17.000000,   [13 trans_cross_sect_No ]
10.100000,   [10 Zg_true         ]
160.000000, [14 Visual ship length ]
```

<Propeller data>

```
6.700000,   [1 propeller_diameter ]
1.000000,   [2 propeller_pitch_ratio ]
4.000000,   [3 numbers_blades       ]
0.494000,   [4 propeller_area_ratios ]
1.000000,   [5 numbers_propellers   ]
18.000000,   [6 distance_between_propeller_axes]
1.000000,   [7 dist_betw_prop_axis_and_base ]
2,          [8 rotation: 1-R 2-L     ]
```

<Rudder data>

```
25.200001,   [1 rudder_area          ]
7.300000,   [2 rudder_height         ]
1.000000,   [3 numbers_rudders       ]
29.100000,   [4 dist. rudders,or totalArea ]
0.223000,   [5 compensation_coefficient ]
7.300000,   [6 dist_betw_up_tip_chord_and_base]
```

```

7.300000, [7 height_balance_part      ]
0.0, [8 turnrate (NOT USED)           ]
<Approached speed table>
20.000000, [1 full speed ahead      ]
15.000000, [2 maneuver speed ahead]
12.500000, [3 mean speed ahead      ]
10.000000, [4 slow speed ahead      ]
6.000000, [5 dead speed ahead       ]
93.000000, [6 full RPM ahead        ]
69.699997, [7 maneuver RPM ahead    ]
58.10000, [8 mean RPM ahead         ]
46.500000, [9 slow RPM ahead        ]
27.900000, [10 dead RPM ahead       ]
<Engine data>
1, [engine_type: 1-diesel 2-steam]
19500.000000, [1 dizel_power        ]
0.870000, [2 part_power_ahead      ]
1.000000, [3 part_rpm_ahead        ]
40.000000, [4 deley_regim_regims]
0.620000, [5 part_rpm_contr        ]
<CPP pointers data>
16.000000, [1 full speed ahead      ]
10.000000, [2 maneuver speed ahead]
9.000000, [3 half speed ahead       ]
8.000000, [4 slow speed ahead       ]
6.000000, [5 dead speed ahead       ]
-13.000000, [1 full astern pointer   ]
-8.000000, [2 half astern pointer    ]
-4.000000, [3 slow astern pointer    ]
-2.000000, [4 dead astern pointer    ]
0.000000, [5 stop pointer           ]
2.000000, [6 dead ahead pointer      ]
4.000000, [7 slow ahead pointer     ]
5.000000, [8 half ahead pointer     ]
6.000000, [9 maneuver ahead pointer]
13.000000, [10 full ahead pointer    ]
1.200000, [11 full_ahead_cntrl_pitch]
120.000000, [12 init_rps_cntr_pitch ]
<Sea data>

```



```

0.000000, [1 Mean draft to water depth ratio]
0.000000, [2 Wind velocity, 5.00 OK]
270.000000, [3 Wind direction ]
0.000000, [4 Current velocity ]
270.000000, [5 Current direction ]
0.000000, [6 Wave height, sea state, 0 to 9 ]
0.000000, [7 Wave direction, was 270 ]
<Bow thruster data>
500.000000, [1 bow_power ]
3.100000, [2 hydr_area_bow_trsr ]
3.100000, [3 stream_area_bow_trsr]
95.000000, [4 coord_bwt_axise ]
20.000000, [5 bow_time ]
<Stern thruster data>
500.000000, [1 strn_power ]
3.100000, [2 hydr_area_strn_trsr ]
3.100000, [3 stream_area_strn_trsr]
-95.000000, [4 coord_strn_axise ]
20.000000, [5 strn_time ]
<Initial values>
0.000000, [1 Velocity_in_x_direction ]
0.000000, [2 Velocity_in_y_direction ]
0.000000, [3 Angular_velocity_about_z_axis]
0.000000, [4 Angular_velocity_about_x_axis]
93.000000, [5 Rotation per minits ]
0.000000, [6 Head angle, was 0 ]
0.000000, [7 Roll angle ]
0.000000, [8 Distance_CG_in_x_direction, 1.4]
0.000000, [9 Distance_CG_in_y_direction, 1.2]
<Maneuver type>
1.000000, [1 type: 0-free 1-Circulation 2-Zigzag 3-Spiral_test ]
1.000000, [2 discretization step (sec, float number format)]
30.000000, [3 print time: ship body display time (sec)]
2.000000, [4 Max_mnv_r_time_min ]
50.000000, [5 Max_rudder_deflection, 0]
30.000000, [6 Angle_of_zig_zag_maneuver_switch]
10.000000, [7 motion equations results display time (sec)]
<Regimes>
9, [1 One engine: initial regime: 0-full astern 4-stop 9-full ahead]

```

```

9,  [2 One engine: ordered regime, 4]
4,  [3 Left engine: initial regime]
4,  [4 Left engine: ordered regime]
4,  [5 Right engine: initial regime]
4,  [6 Right engine: ordered regime]
<Added Mass>
0.02 [admassx_coeff, admassx/mMass]
0.7  [admassy_coeff, admassy/mMass]
0.7  [admassz_coeff, admassz/mMass]
0.002 [adinex_coeff, adinex/mMass/mLength**2]
0.7   [adiney_coeff, adiney/mMass/mLength**2]
5     [adinez_coeff, adinez/mMass/mLength**2]
<Print Data>
1,  [1 Hull force: 1=yes, 0=no]
1,  [2 Rudder force]
1,  [3 Propeller force]
1,  [4 Kinematic]

```

4.10 Output

The simulation results are saved in a **trace** file, named by the user (the default name is **ship**.dat**). The following quantities are saved.

<i>time</i>	<i>Xcoord</i>	<i>Ycoord</i>	<i>Heading</i>	<i>Rudder</i>	<i>xYaw</i>	<i>zYaw</i>	<i>Roll</i>	<i>Drift</i>
0	+0.0000	+0.0000	+0.0000	+0	+0.0000	+0.0000	+0.0000	+0.0000
1	+10.2794	+0.0011	-0.0066	+0	-0.0002	-0.0001	-0.0114	-0.0126
2	+20.5581	+0.0024	-0.0188	+0	-0.0003	-0.0002	-0.0271	-0.0264
3	+30.8361	+0.0033	-0.0360	+0	-0.0002	-0.0003	-0.0387	-0.0411
4	+41.1136	+0.0031	-0.0575	+0	-0.0000	-0.0004	-0.0398	-0.0562
5	+51.3904	+0.0011	-0.0829	+0	+0.0002	-0.0004	-0.0281	-0.0717
6	+61.6665	-0.0033	-0.1117	+0	+0.0004	-0.0005	-0.0060	-0.0872
7	+71.9421	-0.0106	-0.1437	+0	+0.0005	-0.0006	+0.0202	-0.1028
8	+82.2171	-0.0214	-0.1786	+0	+0.0004	-0.0006	+0.0429	-0.1183
9	+92.4914	-0.0363	-0.2163	+0	+0.0002	-0.0007	+0.0559	-0.1337
10	+102.7651	-0.0556	-0.2565	+0	+0.0000	-0.0007	+0.0566	-0.1488
11	+113.0382	-0.0799	-0.2991	+0	-0.0002	-0.0007	+0.0469	-0.1636
12	+123.3108	-0.1096	-0.3440	+0	-0.0003	-0.0008	+0.0321	-0.1781

5. Tugboat Simulation*

Tugboats can be simulated in DYNASIM[®] either as point forces or as a user controlled ship.

5.1. Tugboats Modeled as Point Forces*

Point forces can be applied to a ship to simulate the tugboats acting on that ship. The representation of a point force acting on a ship is shown in Fig. 20.

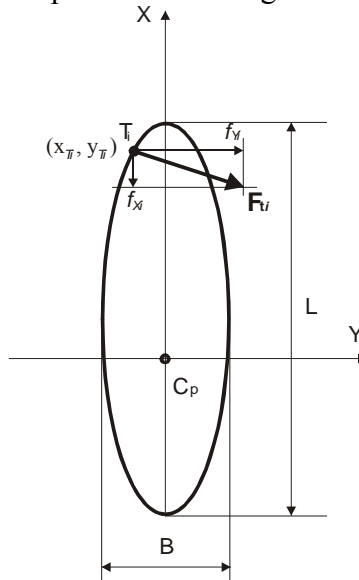


Figure 20. Tugboat as a point force acting on a ship.

B and L are the beam and length of the ship, T_i is the contact point of coordinates (x_{Ti}, y_{Ti}) between tugboat i and the ship (note that the origin of the X-Y coordinate system is located at the ship center of gravity C_p), F_{Ti} is the force acting on the ship by the tugboat i with f_{xi} and f_{yi} its components along the X and Y axes.

* This expanded capability for tugboat interactions is available in the Tugboat Version only.

The point forces are input by a user through the *Tug Point Force Table* dialog window as shown in Fig. 21 in which each point force is specified by its location (x/L and y/B are the x and y normalized by L and B respectively) and magnitude (F_x and F_y are the components f_{xi} and f_{yi}). The user can specify how many point forces are applied to the ship by editing the *Number of force points* edit box. Up to 20 point forces can be applied to a ship simultaneously through the dialog window.

	X/L	Y/B	F_x (kN)	F_y (kN)
1	0.00	0.00	0.000	0.000
2	0.00	0.00	0.000	0.000
3	0.00	0.00	0.000	0.000
4	0.00	0.00	0.000	0.000
5	0.00	0.00	0.000	0.000
6				
7				
8				
9				
10				
11				

Status: Applying tug forces

Figure 21. The dialog window of *Tug Point Force Table*.

The user can choose to apply the tug point forces to the ship instantly after its input to the table by checking the checkbox *Apply force instantly*. If the checkbox is left unchecked, the user can apply or stop applying the tug point forces to the ship by toggling the *Apply/Stop tug forces* Button. The message shown in the *Status* at the bottom of the dialog window indicates the current status of the tug forces.

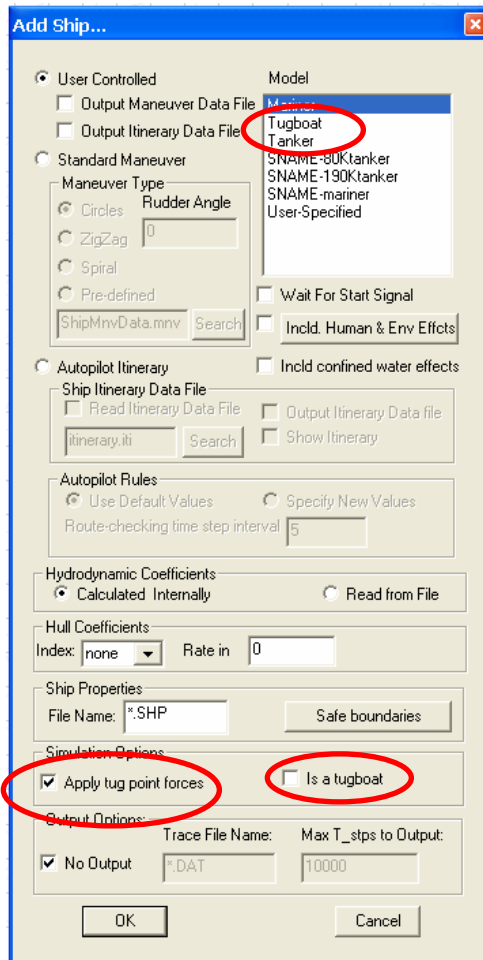


Figure 22. The Add Ship dialog.

The *Tug Point Force Table* dialog window will be automatically activated when it is linked with a ship and the point forces will apply to that ship. The user can link the point forces with a ship when it is newly added to the simulation or is selected after it has been added to the simulation. To link with a new ship, the user can check *Apply tug point forces* in the *Add Ship* dialog as shown in Fig. 22. To select or change to a ship that has been added to the simulation, the user can select the *Selector* on the tool bar, point the *Selector*

on the ship of interest, right click the mouse to activate the *Modify Ship Dialog* as shown in Fig. 23, and then click the *Apply tug point forces* button.

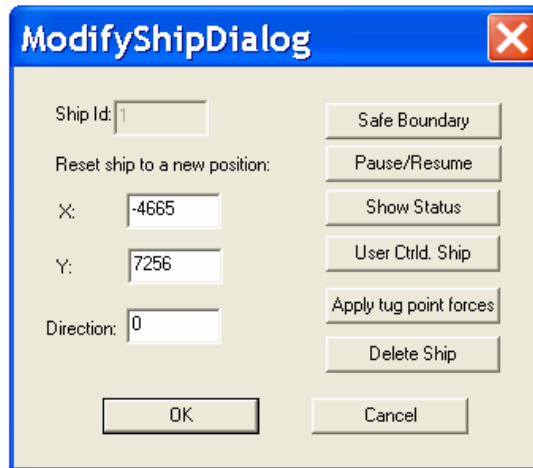


Figure 23. The Modify Ship Dialog.

5.2 Tugboat Modeled as a Controlled Ship^{*}

The ship-tugboat interaction model implemented in DYNASIM[®] will be activated when any one of the two interacting ships is a tugboat. A tugboat can be added to the simulation through the *Add Ship* dialog as shown in Fig. 22. The ship is treated as a tugboat if the checkbox *Is a tugboat* is checked. The ship model list has also been expanded to include a tugboat ship model (When the tugboat on the list is selected, the *Is a tugboat* checkbox is checked automatically).

Once the tugboat is launched into the simulation as a *User Controlled Ship*, the user can control the tugboat using the control panel to perform the tugging process.

^{*} This expanded capability for tugboat interactions is available in the Tugboat Version only.

6. Feedback

DYNASIM[®] is under constant development, any feedback from users is highly appreciated. Customers will be notified of the newest versions when they are available.